

*To William Crawford Esq. M.D. from his old & most
sincere friend & servant*

The Author

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ON THE
F I S H
ENCLOSED IN
S T O N E
OF
M O N T E B O L C A.

BY THE REVEREND GEORGE GRAYDON, LL.B.
M.R.I.A. AND SECRETARY OF FOREIGN CORRESPONDENCE.

D U B L I N:
G E O R G E B O N H A M.

1794.

On the FISH enclosed in STONE of MONTE BOLCA.

IT is impossible for those who have not seen and examined the fossil fish of Monte Bolca to form an adequate idea of that most curious phenomenon of natural history: In this, as in every thing else where the sensible qualities of bodies are concerned, it is well known that description, however exact, must come far short of conveying the impressions that are given immediately by the senses*. That such is remarkably the case in the present instance, I can testify from experience;

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* For this reason, and to supply the defects of my pen, I have, with the permission of the Academy, placed a few small specimens of these fish in their museum. To them I beg to refer such members as wish for more accurate ideas than it is possible for words alone to convey. An engraving of some of these is annexed to this paper.

for though I was not unacquainted with these singular productions by description, I was not less forcibly struck, on first seeing a collection of them at Verona in January 1791, than if I had never heard of them before. As I had not, at that time, leisure to pay much attention to them, or to make the minute inquiries which they seemed so well to deserve, I determined, if I should again pass through this part of Italy at a favourable season for the purpose, to visit, if possible, the place where they were found, as well to verify the fact, as, from an examination of the situation and other particularities of the spot, to endeavour to form some conjecture as to the origin of a circumstance so extraordinary.

THIS opportunity occurring in the month of June following, I took up my residence for some days at the town of Arzignan in the Vicentine, by the recommendation of the well-known Abate Alberto Fortis*, and from thence occasionally made excursions through the neighbouring hills, under the guidance of

* I was much indebted to the hospitality and kind attention of the Abate Fortis to my accommodation in every respect, during the short time that I had it in my power to spend in examining the Euganean hills, and other curious districts of the Venetian territory. It is much to be regretted that the many interesting papers which this gentleman has given to the world, at different times and in various shapes, on particular parts of the north of Italy, have never been collected into one publication. Many valuable works of Signior Giov. Arduino of Venice have also appeared in the same scattered manner, which, though written some years back, would form a most useful collection of accurate local descriptions and observations. At present it is very troublesome and difficult to procure many of the writings of these authors, even in the countries where they were published.

of peasants well acquainted with the country. In one of these I had the pleasure of seeing the quarries of fossil fish at Monte Bolca. Of these, and such circumstances relating to them as the very short time I could spend there enabled me to collect, I shall proceed to give the Academy the best account in my power; relating, first, the facts as I found them; and then the inferences which they suggested to my mind as to the possible immediate causes of this striking phenomenon.

MONTÉ BOLCA lies on the border of the Veronese territory, about fifty miles W. N. W. of the Lagunes of Venice, which, I believe, is the nearest sea. I am not informed of its height, but it must be pretty considerable, as I understood from the inhabitants that the climate is too cold for the growth of the country fruits which are common about every peasant's house in the lower grounds, such as apricots, apples, cherries, &c. as well as vines. It forms one of the chain or ladder of secondary hills, which, from some distance within the adjoining Vicentine, rise gradually above one another to the Alps of the Bishopric of Trent.

GREAT part of this tract of country has been considered by many Italian, as well as other naturalists of eminence that have visited it, as covered with productions of extinct volcanoes. The supposed lava of these districts differs essentially from that of which the Euganean hills are composed; this latter is of a whitish, yellowish or brownish grey, rough and coarse in the grain, and mixed with numerous minute frag-

ments of what they denominate schorl and felt-spar; whence Sir John Strange, Monsieur de Dolomieu, and others, have called it granitical, though unlike granite in many important points: But the supposed compact lava of the Vicentine and Veronese is black, or dark blue, of a close and rather fine grain, even, and almost homogeneous, except that it sometimes contains a few fragments of schorl, and is wholly of the argillaceous genus, and of the trapp or homblend species; and in short almost perfectly resembles our basaltic stone of the county of Antrim, and the N. W. of Scotland. The basaltic columns of San Giovanni Ilarione, described by Sir John Strange, lie not many miles from Bolca, on the side of a valley that leads to it, and the summit of this hill itself was, many years ago, discovered by Abate Fortis to be crowned with a great mass of tolerably defined columnar basalte.

THE whole of the hill, as far as I could observe, seems to be composed of similar, or at least of argillaceous matter, except the quarries in which the fish are found, which are calcareous, and lie at about half a mile from the summit. Besides the dissimilarity of these to the other materials of the hill, it is further important to remark that they do not form a continued stratum, but lie in great and wholly detached and distinct masses, as it were accidentally imbedded in the side of the hill, set in a loose rubble of argillaceous, and the same kind of calcareous fragments, the whole more or less in a state of decomposition.

THE mass that has been most worked stands near the point of an angle formed by two deep channels that have been worn by a greater and less torrent that meet there. The height of its face above the present surface is, as well as I can recollect, about fourteen or fifteen feet; but as it cannot be determined to what depth it may be buried in the ground, it is not easy to judge what its positive height or breadth may be. The length of the face, I should suppose, for I did not measure it, may be two hundred feet or upwards. The stone is of a schistous or flag-like structure, the leaves lying in the same direction, and parallel to each other; but this direction, it is to be remarked, is neither horizontal, nor coincident with the slope of the hill.

I GOT some of the people that are usually employed in working the quarry to bring their tools, and shew me their manner of operation, as well to be informed in this, as, if possible, to see some fish actually opened in the stone. Unfortunately the day proved very wet, which prevented my having more than two or three workmen, but from these I procured almost all the information and satisfaction I could expect. I spent nearly three hours on the spot, during which time I not only saw some fish, as well as a few remains of marine vegetables found by the men, but had the pleasure to find some myself, opening with my own hands stones which contained them. These I collected, packed and brought home; and some of them are now in the museum of the Academy: They are but small indeed, and in the mutilated state that accident presented them; but, I believe, they

they are amply sufficient to authenticate the principal fact, if any one should be found to doubt it.

THE manner of working these stones is by detaching from the face of the quarry moderate sized blocks, which are then drawn out, set an edge, and quickly split with sharp-sided hammers or wedges, the workmen glancing between the leaves, to observe if there be any mark of fish, or other organic substance; when they discover such, if they happen to be shattered, as they generally are, by the rude manner of opening, and the fragile texture of the stone, they set about to collect all the fragments that compose the piece as carefully as possible, detaching also from the great stone such parts as may remain adhering to it. When their day's work is finished, they bring their collections to their houses, until they happen to go, either to market, or on any other occasion, to Verona, when they take them in baskets, just as they are, to the proprietor of the soil, who is their landlord and employer; or frequently, I believe, to sell underhand, for their own profit, to some naturalist there, or to some of the shops that vend these productions. Those who receive them in this manner from the peasants are then obliged to employ a skilful stone-cutter, to find and arrange together the several fragments that compose each piece, and finer or cement them on another stone of the same kind, which is sometimes done with such art and exactness that it is not easy to discern where they have been joined; and thus the specimens are made up for cabinets or for sale.

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BESIDES this principal quarry or mass, from which almost all the fish yet found have been extracted, the workmen shew two or three others of the same stone seated in the sides of the adjoining banks, some of which, they said, had been discovered not long since: They had all been tried, and were found precisely of the same kind, and equally containing fish; but the people being very poor, and no funds allowed for the business, which would require considerable expense to clear away the bearing, and prepare for working to advantage, nothing of consequence had been done.

THE soil of these quarries had been the property of a Signor Bozza, formerly an apothecary of Verona, who purchased, or took it on lease, many years ago, and whose cabinet is too well known to all the naturalists of Europe, and has been too long one of the principal objects of the attention and admiration of those who pass through this town, to make it necessary for me to enter into any detailed description of it; but while I was there his whole collection, with the quarries, was agreed for, and, as I was informed, purchased, at a very considerable expense, by the Marquis Gazola, of that city. This gentleman had already a very fine collection of his own, containing many fish that were not in Bozza's. He was so kind as to give me a catalogue of these, in addition to Bozza's printed catalogue, both of which, as I have not seen them in any publication, I shall subjoin to this paper*. They will be found to contain together

* I give these catalogues just as I received them from Mr. Bozza and the Marquis Gazola, possessing neither sufficient knowledge of the natural history of fishes

gether the scientific names of upwards of one hundred different species of fish, with distinct references to the authors by whom they have been described, and the plates in which they are represented; so that those who will take the pains may, by actual comparison, judge of the resemblance and propriety of denomination. But what is most remarkable is, that these fish are described, by the authors referred to, as the modern natives of various seas, most remote from each other; and not of Europe only, but of Asia, the Indian Ocean, the South Sea, Africa, North and South America; and in addition to these some few of sweet water*.

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fishes to enable me to judge whether the cabinet specimens have been faithfully denominated or not, nor having had time or leisure enough at Verona, though I had understood the subject, to go through such an examination. I will not even venture to answer whether some tricks may not have been played by the stone-cutters who arrange these specimens:—Whether, for instance, they may not, in some cases, have contrived to suit pieces of different fish to each other in such a manner as to form a whole that might correspond with the plates in books of natural history. Such an idea has been suggested, perhaps founded on the well-known dexterity of Italian workmen in similar fabrications; but in the present instance, though I will not say it is absolutely impossible, I really think it so very improbable as to deserve little serious attention.

* Mr. Bozza, in a paper published by him a few years ago, speaks of his collection as follows: “ In my cabinet, which contains upwards of six hundred fish
“ of different sizes, all extracted from Bolca, there are more than one hundred
“ whose kinds are known, which differ from each other in genus and species, and
“ many others besides to which similar living ones have not yet been discovered.” In another passage he adds, “ The first decade of fish published by M. Broussonet has
“ ascertained to us that many of those found at Bolca are natives of the South
“ Sea—of these I have four, which agree exactly in form, in proportions and in
“ fins.”

THAT all these should be found, as is asserted, perfectly and unequivocally defined within the narrow compass of the quarry of Monte Bolca, must surely be considered a very astonishing circumstance, and such as I believe can scarcely be paralleled in what has hitherto been discovered of the natural history of our globe.

It has been already observed, that the stone in which these fish are found is calcareous, and of a schistous structure, capable of being split into flags or laminæ of various thickness and dimensions. Most mineralogists who have mentioned it call it a marle or marley schist. Its colour is whitish, yellowish or bluish grey; the grain, though not coarse, is very dull and earthy; it varies a good deal in hardness, but in general easily yields to the knife, though not to the nail. Every part of the mass, whether immediately surrounding fish or not, on being struck or scraped hard, emits a peculiar kind of fetid smell which cannot easily be defined. It is somewhat of the kind, yet differs considerably from the smell of the lapis suillus or swine-stone. It is not properly hepatic, unless perhaps it might be called animal-hepatic*.

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“fins with four described by M. Broussonet, which are peculiar to the sea of Otaheite, which are the *Polynemus plebeius*, or Emoï of the Otaheitans; the *Gobius strigatus*, which they call Jaipoa; the *Chætodon triostegus*, and the *Gobius ocellaris*.”—These perfectly correspond with the fish given by Sir Joseph Banks to M. Broussonet.

* Abate Fortis observes the same thing of the calcareous stone, containing many shells of the valley of Ronca in the Veronese, at no great distance from Bolca.

“Ever

THE fish are of a dark-brown colour, and therefore appear very distinctly on the light ground of the stone; they lie flat between the laminæ; their profile, and their several parts, little, if at all, distorted from their natural shape and dimensions, except that in some cases the stone inclosing them seems to have suffered some little disturbance, as if by settlement, after their inclosure, by which they are found, at times, somewhat fractured, and the parts a little disjoined. Their whole form is well defined, but the harder parts, such as the head, fins, spine, with the bones that branch from it on either side, and indeed all the bones in general, as well as in some the scales, are remarkably well expressed. The dark-brown matter composing these fish remains distinct, and may be picked off from the stone, and projects in proportion to the thickness of each part in its natural state. It is hard, brittle, and rather glossy through its substance, except in some of the grosser bones, such as the joints of the vertebræ, which, though of this appearance externally, are found, when broken, to consist internally of laminar crystallized calcareous spar.

To those who may not have an opportunity of seeing specimens of these fish, it is further proper to mention, that when the leaves of stone that enclose them are opened, the forms
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“ Every stroke of the hammer or other solid body,” says he “ disengages from this
“ stone a most fetid cadaverous odour, by no means bituminous, but a true smell
“ resulting from decayed animal putrefactive matter. *Di vero fracidume animale.*”
Fortis Della Valle Vulcanico-Marina di Ronca, p. 24.

are found equally announced on each of the opposite sides, with this difference however, that more or less of the prominent brown matter of the bones, fins, and other parts, sometimes adheres to one leaf and sometimes to another, or frequently is divided between both; the prominences on one side, when the pieces have been carefully and well put together, being exactly answered by corresponding hollows on the other; and thus the more valuable specimens are formed in duplicates. This, properly considered, must surely make the difficulty of fabrication, in such instances at least, so great, that it may well be deemed insurmountable; and if not from the nature of the case itself, yet decidedly so at such an expense, as either the capital of the late proprietor, or the prices at which I understood he sometimes parted with specimens, would bear; some in his, as well as in Marquis Gazola's own cabinet, were of an immense size; certainly, as the catalogue mentions, fully three feet long.

I HAVE now related all the facts worthy of notice which I recollect to have fallen within my observation relative to these curious fossils; and I trust I have done so faithfully and without a view to any particular theory or system of explanation: In fact, I visited the spot where they are found wholly unprejudiced as to the manner of accounting for the phenomenon, and indeed wholly uninformed, as I still am, of any attempt to account for it, except on vague and general principles*. What

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* Whether the following attempt to assign immediate causes for the production of the phenomena now described can lay claim even to novelty, as a recommendation

I shall now venture to lay before the Academy on this subject, I can therefore say with confidence, is purely the result of inferences suggested to my mind by the appearances of the objects themselves, and their several concomitant circumstances.

I SUPPOSE no one that has attended to the description of these fossils, and still less that has examined the specimens themselves, will doubt that the forms which they exhibit are the remains of once actually existing fish.

BUT these, it should be well remarked, differ essentially from the forms of fish that are frequently found in argillaceous schistus, as well as from what are commonly called petrifications of shells, &c. which abound in most lime-stone strata. In this latter case we have seldom more than the mere external shapes preserved; the substance is wholly changed, and what remains
resembles,

tion to the attention of the Academy, I cannot positively assert, my information in these subjects being very limited; I can only say, that nothing of the kind has fallen within my observation. I have consulted some modern Italian writers of mineralogy and natural history, but find them very concise in what they say of these fish. P. Petrini, the very worthy mineralogical professor of the Collegio Nazzareno at Rome, has an appendix to the 2d vol. of his Gabinetto Mineralogico del Collegio Nazzareno, published at Rome in 1792, which treats expressly of petrified remains of animal and vegetable substances, but contains nothing relative to these. Signior Bozza, in his paper above quoted, which is entitled, Della Rivoluzione sofferta dal Globo Terraqueo, speaks only of remote and general causes: And the Marquis Gazola, to whom I mentioned at Verona the outlines of the explanation here attempted, immediately after my visit to Bolca, seemed wholly unacquainted with any thing similar. These circumstances, particularly the last, led me to presume that the ideas here given had not been anticipated, and emboldened me, on that ground, to submit them to the Academy.

resembles, in general, a portion of the same matter of which the mass consists, cast, as it were, into a mould formed by the outside impression of the shell*. In some cases the shell-formed nucleus differs from the surrounding matter, by being of a brighter colour, and of a sparry texture; but, in almost all, the original shell that gave the impression exists no longer as such, nor any certain remains of it. The same holds equally in the former case, a bare impression of fish only remaining, and seldom any thing that can be thought to resemble any part of the substance that gave it†; whereas in these of Monte Bolca, not only the

* It is to be observed that I speak here only of the petrified shells that are found imbedded in solid lime-stone strata, and forming part of the stone; yet even these shells and their fragments sometimes, though rarely, retain their natural substance and appearances, as in the beautiful *Lumachella di Carinthia*; but in less compact beds, such as sand, marle, clay, &c. shells are often found little changed from their original state.

† Impressions of fish, partly in argillaceous and partly in calcareous schistus, have been found in a variety of places: In Syria, between Batron and Diebail; in the mountains of Castravan, near Baruth; in Antigua, nine hundred feet above the level of the sea; at Monte Viale in the Vicentine; at Sapezzano in the Campagna of Rome; in the valley of Glaris; at Mont Pilate, in the canton of Lucern; near Angers; and at Eichstedt in Franconia. These are mostly sea fish. River fish are found in the copper flats of Eisleben, in the county of Mansfeld, near Pappenheim in the Pallatinate, and at Æningen in Suabia.—See P. Pinis *Mem. sulle rivoluzioni del Globo terrestre*, in the 5th vol. of the *Società Italiana* of Verona, p. 238. Mr. Raspe informs me that a Baron Francis Beroldingen has given, some years ago, a very circumstantial and satisfactory account of the fish found at Æningen; but I have not seen his work. He also tells me he saw, many years ago, a specimen equal to any of the Bolca fish in the possession of the late Professor Green at Cambridge, found in some part of Leicestershire, but he could not learn the exact place.—He adds that he has lately found numberless impressions of fish in

the forms are preserved uncommonly perfect, but even every residue of animal matter that could be expected to resist the natural destructive causes, and the immense lapse of time in any, the most favourable circumstances, is found still existing. The prominent brown matter with which all the harder and less corruptible parts of the animal are so strongly marked in the stone, and which may be detached from it with the point of a knife, inspection alone will determine to be of a nature wholly different from the inclosing substance, and as far as can be presumed without analysis, to be the actual dry remains of the animal bodies, in such a state as almost to authorize their being called fish-mummies†.

BUT when we recollect of what very soft and corruptible materials the bodies of fishes are composed, not consisting of the firm

in bituminous schistus, in Caithness on the river Thurso near Carfgo; and on the slope of Gerston-hill. To these I will add a fish engraved and shortly mentioned by Doctor Nash, in his History of Worcestershire, p. 236, and found in a stone-pit of the parish of Cleve or Clive in that county, for the communication of which I am indebted to the Bishop of Dromore. With regard to most of these the ingenious M. Volta, in his Elements of Mineralogy, published in 8vo. at Cremona, 1787, p. 292, observes, after shortly mentioning the fish of Mount Bolca, that in Germany and elsewhere slate and calcareous stones are found containing the impressions of the bones or skeletons of various species of fish, the rest of the animal being destroyed; and these impressions he denominates Typolites, to distinguish them from those which he calls peculiarly Ichthyolites, which term he confines to such specimens as exhibit the animal itself either dried or petrified; and of these last the only instance that he gives is the fish of Bolca.

† M. Volta calls the manner in which these fish are preserved a Natural Embalming.—Elem. Min. p.

firm muscles and tendons that invest the bones of land animals ; when we call to mind in how very short a time such of them as die, or remain dead in their own element, do actually corrupt, and run into such complete dissolution as to obliterate the whole form, the bones only remaining, a fragile and imperfect indication of the species to which they had belonged ;—and further, when we find, in the cases just now mentioned, that substances so hard and durable as shells have not been able to withstand the corroding influence of time, must it not astonish us to find, that in this instance, nature has been able to effect more than perhaps the most studied art could have accomplished, and will it not force us to have recourse to more than ordinary causes to account for a phenomenon so extraordinary ?

THE very perfect preservation of the living form which we see in these specimens, I consider as a certain proof that the animals could not have been long dead before they were enclosed in the matter that surrounds them ; from the same circumstance it follows equally, that this matter must have been in a very fine and pulverulent state, suspended in, or subsiding from the water in which the fish swam not long before. Here then we have next to a demonstration, of two inferences of most important and fundamental facts, which are of material consequence to our present enquiry : First, that these animals were alive, and of course that the water in which they were was clear and fit for the support of their life, at a very short period before they were enveloped in the matter of their present stony enclosure ; and secondly, that this matter must have been very suddenly diffused through that water in a pulverulent state, from

from whence speedily subsiding, it caught and enclosed the fish now dead, and probably deriving their death from this very cause.

THESE inferences being admitted to follow, from the preservation of the exact form as we see it in these fish, we may advance a step farther, and observe, that as not only the form is preserved, but a remarkable proportion of the very animal substance, to account for this effect we shall find it necessary to suppose, that the enclosing matter must have been of such a nature, or in such a state, as to fit it for the speedy absorption of the softer and more pulpy parts of these fish, as fast as they became absorbable.

To see the necessity of this conclusion, let us in the first place recollect that the whole operation must, from the nature of the case, be conceived to have taken place in or under water; either then we must suppose that the dead fish continued floating at large, until the process of putrefaction had taken place, in which case, indeed, the conveyance of the corrupting animal matter is easily accounted for; but, with it, the forms, not to say those parts of their substance that are seen to remain, would be wholly lost; or else we must imagine them arrested, before putrefaction, in the deposition of their present stony bed, by which all access to the water as the vehicle of the soft putrefying parts is cut off, and we must look for some other mode of accounting for the speedy removal of these parts; but such removal, by some means or other, is absolutely necessary to be supposed; for should this tender animal matter rest any time unremoved,
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it would not only soon infect and involve all, but the most solid bones perhaps, in one complete corruption and dissolution, and consequently leave no other vestige of the animals remaining; but, by the disengagement of putrid air, or of the different species of gases produced by the putrefactive fermentation, either the surrounding matter must be puffed into cavities and air-bladders; or, if the medium was sufficiently yielding to admit these gases to collect and force a passage upwards, such an intestine motion must be produced, as would have greatly disturbed, if not destroyed, not only the regular laminar structure of the stone, but the very forms and substance of the fish as we see them, contrary to experience, and the actual state of the facts.

FROM these considerations therefore it seems just to conclude that the bodies of these animals did not undergo any simultaneous putrefaction; but as it is clear that their oily, mucilaginous, and other soft parts must have been conveyed away, to have produced this effect, without general putrefaction, in the circumstances here stated, I conceive can only be explained on the supposition of a rapid absorption of these by the inclosing matter, as fast as they become capable of it.

WE are now to look for a cause adequate to the production of the several effects, which, from the above statement, appear to have taken place,—a cause which shall account for the sudden, and, as I may call it, unexpected diffusion in a part of the sea, of the kind of stony matter that we find inclosing these fish, in a pulverulent form, and in the immense quantity indicated

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by the bulk of the mass; for their immediate loss of life and speedy inclosure in a bed of this matter--and for such a state of it as should render it capable and fit, though immersed in water, for the absorption of the softer animal parts before fermentation could arise, as well as for leaving the harder and less absorbable portions of their substance undestroyed, and in such a state as to resist the no less destructive influence of succeeding time.

AND here we are naturally led, by the quality and circumstances of the inclosing stone, to a simple cause, which, though it might be too much to assert to be demonstratively the real one, yet I believe will be allowed fully equal to the effects, and perhaps I might venture to say, almost exclusively so. This stone, it has already been observed, is wholly calcareous, of a light colour, of a grain dull though fine, and wholly devoid of any crystalline or sparry appearance. Now it is well known that lime-stone, whatever its original colour may have been, becomes uniformly white or whitish, on being calcined or burnt more or less to a lime; that after this calcination it immediately flacks or falls into a powder, on being immersed in water; and by agitation is easily diffused in this element, from which, if left in tranquillity, it soon subsides in a pulverulent state; that this diffusion of lime in water quickly deprives of life such fish as happen to lie within its reach; and, in fine, there is every reason to believe, that a deposition of this nature possesses remarkably the quality, just described, of quickly absorbing, even in water, the oily and other soft parts of animals; and, when sufficiently flacked;

flacked, and thus impregnated with animal matter, without destroying the harder and firmer parts*.

THE application of these circumstances is easily imagined, and will be found to correspond remarkably with all the appearances in the case before us. This deposition, gradually and successively conereting at the bottom of the water, may naturally be expected to assume a flag-like or laminar structure; the grain

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* To this, the causticity of lime, and its well-known application to dead bodies, with a view to their destruction, may be objected. On this account it may be looked upon by many as a *total destroyer* instead of a *partial preserver* of animal substances. But besides the diminution of this causticity by diffusion in so great a body of water as our case supposes, we know that it must soon have acquired a sufficiency of fixed air, or of the carbonic principle, from the abundance of animal juices furnished by the immense number of fish contained, to render it mild and prevent its preying on the firmer parts. This may easily be decided by actual experiment:—Mean time I beg to refer the Academy to the subjoined paper, which our learned and ingenious member, Dean Hamilton, who happened to be present at the first reading of this essay, has since done me the favour to communicate, and which contains facts and reasoning so apposite, that I believe they may be considered conclusive as to the objection now stated. That lime, though soaked in water, will still greedily absorb oils or other animal fluids, experience will determine, and its avidity for the carbonic principle will fully explain; add to this the weight, pressure, and consequent speedy condensation of the subsiding mass, and I believe the effects stated may be regarded as highly probable. But if this be admitted, and shall be confirmed by suitable experiments, it will then deserve to be considered, further, whether a greater or less degree of causticity of the inclosing calcareous matter, so far from an objection, may not prove to have been indispensibly requisite to the production of the effects, and, of course, whether the existence of such effects may not, in that case, be found a proof, and a strong one, of that state of causticity, and consequently tend greatly to corroborate, if not to confirm, the whole of the account here given.

too of this new aggregate should be wholly without lustre, as well on account of its calcination, as of its formation by subsidence from, not in consequence of solution in, a liquid menstruum; in which last case alone crystals are known to be produced. This will further easily account for the formation of the calcareous spar found within the prominences occasioned by the joints of the vertebræ, and the other grosser bones; for, these being fresh and found at the first arrangement of the stone, of course excluded the subsiding matter; but in process of time their hollows were filled, and by degrees, as it decayed, their substance replaced, by a successive filtration of water holding calcareous matter in solution, which deposited, plate after plate, its crystalline matter in these cavities. Of the absorption already mentioned, the fetid smell emitted by every portion of this stone on being scraped, will surely be considered as affording a strong presumption, as it perfectly accords with, and would naturally follow from, the supposition, that the whole had imbibed, and been strongly impregnated with, animal matter*.

IN investigating subjects of this kind, whose origin lies so very remote from any thing that either modern experience or historic record can produce, and particularly in a circumstance like this,

* This impregnation would also probably contribute to the concretion of the stone, as it is known to do in cements, floors, compositions, &c. to which cheese, milk, blood, and other animal substances, are often added with this view. A mixture of curd, or whites of eggs, with lime, has been long used as a strong cement to repair broken China.

this, which is so very rare in the hitherto discovered natural knowledge of our globe, the utmost that can be expected is a reasonable degree of probability, deduced, as the case may admit, from more or less apposite analogy. If such analogical reasoning be fairly applied, it is but just to expect that the consequences resulting from it be admitted, until their falsity shall be proved, or a superior degree of probability established on different and more solid grounds. For this reason I shall, for the present, venture to assume as proved what I have just now suggested, and proceed to another link in the chain of causes that may be supposed to have been concerned in producing the effects under examination.

TAKING it then for granted that the sudden diffusion of lime in the water in which these fish happened to be, and its consequent deposition, was the immediate cause of their enclosure, and the origin of this curious quarry, we are next led to enquire in what manner this lime may have been so burned, and suddenly projected into water, which but just before was proper for the support of the animals inhabiting it. And here it is so obvious to have recourse to fire as a proper agent for the calcination of lime-stone, and, from the apparently rapid and unexpected projection of the immense quantity which the thickness of the stratum indicates, to suppose this fire to have been volcanic; that although no suspicion had ever been entertained of the existence of such a cause in the neighbouring country, or of its operation on the adjacent soil, this single case would seem sufficient of itself to have excited such an idea.

THAT

THAT, where volcanic fire exists, it will burst out suddenly, sometimes in one place and sometimes in another, as it happens to find more or less resistance, is well known; it is also certain that the matter of its ejections must be various, as the substances chance to be, that lie within the sphere of its activity, or fall within its vortex. That Vesuvius, for instance, (not to speak of extinct and dubious volcanoes,) has at some periods thrown out an immense quantity of marble, and other calcareous stones, in various degrees of calcination, the best naturalists that have described that volcano assert, and I can fully confirm, both from actual observation, and from the specimens which I collected there, and have had the honour to present to the Academy. Why then may we not suppose that other, and more ancient volcanoes, may have acted upon calcareous matter as well as Vesuvius, and in a greater quantity? The circumstances of the present case seem to demand such a supposition; and if it is not inadmissible on strong negative grounds, it invites our assent by giving a clear and easy explanation of the several effects in question.

ALTHOUGH, for reasons which I shall mention, it appears to me evident that the present situation of the fish quarries of Bolca cannot be that of their original formation, yet the great bulk of the masses that compose them, will not allow us to believe, that they could ever have been seated very remote from their present beds. But as it is abundantly clear, that the place where they were formed must have been covered with the sea, it seems reasonable to conclude that the sea did then approach much

much nearer to Bolca than it does at present*, if it did not wholly cover that hill. But, this supposed, still the immense number and variety of fish that are found inclosed in the very narrow compass of these quarries, so far exceeds any thing that in the ordinary course of nature is to be met with in any sea of the world, that some uncommon cause must have occurred to assemble them thus, whether living or dead. Submarine volcanic commotions once admitted, (and that such may exist the well-attested facts of new islands produced by them; in the Archipelago and elsewhere, sufficiently prove,) may we not, in conformity with the other indications, account for this numerous assemblage of fish in one spot, by supposing that some new eruption of this kind might have driven them from their usual haunts, to take refuge in some place, the most remote they could find, from the disturbing cause; or, having deprived them of life, might have impelled or whirled their bodies into one pool. That the place where they were collected, whether living or dead, and in which they were buried in their calcareous inclosure, was not very remote from land, seems inferred by the mixture of river fish with those of the sea. This circumstance, as it further proves the existence of rivers at that period, evinces also that of hills raised much above the level of the sea, from whence these rivers derived their sources, and probably at no great

* I have already observed that the nearest sea is now upwards of fifty miles from Bolca.

great distance from this spot*, which stands at the foot of the Alps of the country of Trent. These fish then possibly may have been forced or drifted into some recess adjoining their present situation, into which the newly erupted volcano suddenly poured an immense quantity of calcined calcareous matter, and thus gave rise to the several consequences that I have already described.

It now only remains to trace the inferences that arise from the consideration of the general circumstances and situation of the masses that form the fish-quarries of Monte Bolca: These, I have observed, lie in detached bulks, set in different spots of the side of this hill; but the soil of Bolca is wholly argillaceous, its native stone resembling our basalte of the county of Antrim; and as far as I could see, or learn from the inhabitants, beside the quarries in question, it does not contain any calcareous matter whatsoever. Now these, though near each other, lie at somewhat different heights, and different inclinations of their laminæ to the horizon, as well as to the surface of the hill, and coincide with neither of these directions; from whence alone it seems evident that they could not have been formed in the places where they are now found; add to this their flag or laminar

* P. Pini, in his memoir above quoted, p. 242, says, that with the fish of Bolca are often found impressions of sprigs and leaves of various trees. How far this may be well founded I cannot pretend to say, not having myself seen at Bolca, or in the collections at Verona, impressions of any other than *marine* vegetables. He does not say either, that he had seen such impressions. Soc. Ital. di Verona, toni. 5.

laminar structure, the leaves all parallel to each other, and perfectly straight or flat; their composition, and the nature of their contents, all strongly attesting formation in a horizontal position:—and their want of continuation, the extremities being suddenly and sharply cut off; so many circumstances concurring, and tending all to the same conclusion, give it a degree of evidence that may almost be called demonstration.

BUT if it be admitted that the present situation of these masses must be regarded as foreign from their native place of formation, we have, in this, another object of investigation, no less remarkable in itself than interesting to the natural history of that country.

THAT these masses, in their original position, must have formed part of a continued and horizontal stratum of some considerable extent, seems highly probable. If the account just now given of the origin of this stone be well founded, the thickness of the stratum evinces that the quantity of calcareous matter, suddenly poured into the superincumbent water, must have been immense:—But this matter, immediately on its subsidence being pulverulent, or in the state of a soft mud, must have lain to a great depth at the bottom of the water, and, from the levelling nature of that fluid, must have been spread out over a greater or less surface, as the shape of the ground, or bottom on which it lay, or the intervention of shores or other obstacles may have permitted. At all events it is scarcely possible to

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imagine any circumstances in which this stratum must not be conceived of a much greater extent than the very circumscribed surface of the quarries of Bolca. Of such a stratum then, these quarries are evidently to be considered as no more than portions or fragments, now completely disjoined from all connection with their native bed: We are next to enquire how these portions may have been so detached.

A NUMBER of circumstances already mentioned leave not a doubt, that this must have happened after the consolidation of the original stratum; for it is clear, that a disjunction of this kind could not have taken place, in any way, without such a concussion and disturbance of these masses, as, if their matter was in any respect soft or yielding, or in any other than a firmly compacted state, must have greatly disarranged their laminar structure, as well as the forms of the fish contained. Their extremities too, instead of being sharp and even, would have been left confused and ill-defined. This matter, therefore, must certainly have lain in its first bed and position, undisturbed, so long at least as was necessary to its perfect consolidation. At some period subsequent to this, it would seem that the whole of the stratum was violently broken up, and immense fragments of it heaved from their natural situation, and dispersed here and there, as in the instance before us. But when we calculate the prodigious forces required to produce the effects here described, we shall not find it easy to assign any other cause, fully adequate to them, but that which we have already had recourse to, namely,

namely, subterraneous fire and explosion; and this we must conceive to have operated, in the present case, with an eruptive force much exceeding whatever has been experienced in the known history of volcanoes*.

I HAVE chosen to represent the separation of these masses, from the stratum of which they formed a part, as brought about, rather by their having been heaved up to their present situation from an inferior one, than by their having been left where they are, while the rest of the stratum was sunk; but I shall not trouble the Academy with the reasons that led me to the one conclusion in preference to the other, as the principal point of enquiry is the nature or quality of the cause, not its precise mode of operation. Now, whatever may have been the manner in which the effects were produced, the immediate cause must, in any case, have been one of great violence; and there are many reasons, besides sufficiency of force, to conclude it volcanic.

It is remarkable that, except these quarries, nothing of the stratum to which they belonged is left, not a trace having yet been discovered, either at Bolca or in its neighbourhood, to indicate where such a stratum had ever existed; all is covered with argillaceous materials, the supposed lavas and other ejections of ancient submarine volcanoes: but this circumstance, until

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* If these effects are supposed to have been produced in air, the forces applied must have been immense; if under water, much less would have sufficed.

it shall be better accounted for, admits of an easy explanation, by supposing that the same eruption which broke up the original calcareous bed, wherever it lay, and raised these fragments of it to their present situations, must, in so doing, not only have disfigured and wholly changed the appearance and shape of the former surface, but may naturally be conceived to have thrown out, at the same time, such a quantity of argillaceous matter as was sufficient completely to bury every other part and vestige of it, except these masses which seem to have escaped, as it were, by accident.

THAT eruptions, and of the kind here supposed, did exist in the district in question at some very early period, naturalists of great eminence have, long since, attempted to deduce from other considerations than those contained in this paper; but as their reasonings in proof of this are immediately connected with a very important mineralogical question, which, though much discussed, remains still in controversy*, I shall not avail myself of their authority, respectable as some names are which I might otherwise adduce in support of this opinion. It is not my intention, nor is it, I believe, at all necessary to my present subject, to introduce here any consideration of the extensive and difficult question to which I allude; for whether the basaltic columns, and other analogous covering of this and similar countries, shall be attributed to the immediate agency of fire or of water, the consequences which I have endeavoured to trace,

from the same cause, need not be repeated here.

* It will easily be perceived that the question alluded to is that *on the origin of basaltic*.

from the examination of the fish-quarries of Bolca, may still hold whatever degree of probability they may be thought entitled to; these consequences, being deduced from local and partial circumstances, and such as are, perhaps, peculiar to that spot, and resting principally on internal evidence, require to be judged specially, and on their own merits, without being subjected to any determination that may be formed, as to the reality of other effects, imputed to the same general cause.

I HAVE now given the Academy the principal observations which arose in my mind from the inspection of these curious quarries, and shall only add, that, as far as they have any weight, they go to infer the remote existence of two distinct æras of great volcanic explosion in this place, one of which at least seems decidedly to have been submarine; the first, when the fish were caught and inclosed in calcined calcareous matter; and the second, after the complete concretion of this matter into stone, when its horizontal stratum was torn up and dispersed.

BEFORE I conclude this paper I cannot omit taking some further notice of a circumstance already mentioned, which seems to hold out a subject of investigation the most striking, and to many the most interesting, that occurs, perhaps, in the whole range of natural history: I mean the great variety of fish collected in one spot, which, from the catalogues, appear to correspond with species now only to be found in seas and climates the most remote from the Italian shores. It would be superfluous to dwell on the analogy which this remarkable circumstance

stance bears to the many discoveries that have been made, not only of shells, but of horns, teeth, bones, and other remains, and even of entire skeletons, of various land animals, partly known and partly unknown, in countries where similar living species have never been observed to exist, and often in climates now wholly unsuited to their constitutions. These extraordinary facts have been long known, and have long excited the attention, and exercised the ingenuity, of naturalists of the most distinguished talents: But, unfortunately, experience has shewn that the paths of speculation to which they directly lead have too often conducted these great men into labyrinths, from which all the efforts of their genius have not been able to extricate them. Hence it would seem, that natural knowledge is not yet sufficiently advanced, nor a sufficient stock of well-attested phenomena yet formed, to enable us to prosecute such extensive and difficult enquiries with good effect. On this account, perhaps, those who really wish to contribute to the substantial improvement of the science, might employ their talents more beneficially, in the humble task of collecting facts, and investigating partial and immediate causes, than in giving the reins to their imaginations, and soaring in pursuit of visionary theories. Of more remote and general causes, posterity, better informed by new facts and observations, in addition to those which we now possess, may possibly form a better judgment than we can aspire to, if such a judgment really lies within the limits of human attainable knowledge. But, at all events, it should not be forgotten, that speculations of this kind are regarded by men of the soundest understandings, rather as amusements of the mind,

mind, and relaxations from severer studies, than as pursuits of much intrinsic importance; and that, at best, they are to be considered as contributing but remotely to the more useful and serious objects of life: But when applied, as we know they have been too often, to excite and diffuse doubts of the most essential truths, and ultimately to sap the foundations of religion, and, with it, of both private and public virtue, order and happiness, and indeed of the very existence of civil society, as too fatal modern experience has shewn, it is not easy to say whether we shall be most struck with the vanity and presumption, the folly, or the wickedness of the attempt, to raise so daring a superstructure on so slender a base*.

* Since this paper was read, Mr. Raspe has pointed out to me a passage in his Preface to Ferber's Letters, translated and published by him in 1776, which had before escaped my notice: Speaking of submarine volcanoes, he says "The petrified fishes are monuments of their heat;" and adds, "some unnatural revolution in their own element must have killed and involved them at once in the sediments of the troubled ocean; on this account, *many argillaceous slate rocks*, filled with petrified fishes, are to be considered as submarine or subaqueous volcanic productions; nay, *many calcareous slates*, such as those at *Bolca, Pappenheim, Eichstaed, Altheim*, and *Mont Libanon*, are, *for the same reason*, to be ranked amongst them."

I transcribe this passage, as it seems to bear some resemblance, though very generally expressed, to the account above given.

The description of Monte Bolca, which we meet with in pages 49 and 50 of the same work, is erroneous in almost every particular. It is as follows: "Bolca is a steep barren hill at twenty miles distance from Verona, *for the most part of stratified limestone*, but *now and then* interrupted by ancient volcanic craters. The limestone contains *variegated flints*, of a red, black, green and white colour. In this hill are found the famous impressions of plants and fishes."

Catalogo Sistematico, dei piu' rari ictioli del Monte Bolca che si conservano nel gabinetto privato del Sig. Vincenzo Bozza, in Verona, nel quale vi sono piu' di 500 esemplari di pesci fossili dello stesso monte, una gran parte ancora da riconoscersi e denominarsi.

O R D I N E I.

Pesci dei Mari dell' Europa.

Ophidium barbatum. WILLOUGH. *Ictb. Tab. G. 7. fig. 6.*

Squalus stellaris. LINN. *Syst. nat. Edit. 13. pag. 399.*

Scomber colias. WILLOUGH. *L. C. Tab. M. 1. fig. 1.*

———— *scomber.* WILLOUGH. *l. c. Tab. M. 3.*

———— *pelamis.* SALVIAN. *de Aquatil. fig. 98.*

———— *thynnus.* ARTED. *Ictb. Gen. 31. Synon. 49.*

Scorpæna porcus. BLOCH. *Ictb. VI. Tab. 181.*

———— *scorpius.* WILLOUGH. *l. c. Tab. 12. X.*

———— *scrofa.* BLOCH. *l. c. Tab. 182.*

———— *Salviani.* WILLOUGH. *l. c. Tab. X. 13.*

Biennius ocellarius. SALVIAN. *l. c. fig. P. 84.*

Gadus carbonarius. BELLON. *de Aquat. Lib. I. pag. 134.*

———— *virens.* VILL. *l. c. Tab. L. 1. fig. 3.*

———— *merlucius.* BELLON. *l. c. Tab. L. 1. fig. 123.*

Pleuronectes limand. WILLOUGH. *l. c. Tab. F. 4.*

Sparus aurata. GRONOV. *Mus. 1. n. 90.*

———— *chromis.* LINN. *l. c. pag. 470.*

———— *pagrus.* ARTED. *l. c. Gen. 36. Syn. 64.*

Trigla cuculus. WILLOUGH. *l. c.* Tab. 5. 2. fig. 2.

Esox sphyraena. LINN. *l. c.* pag. 515.

Muraena myrus. ARTED. *l. c.* Gen. 24. Synon. 40.

Lophius piscatorius. SALVIAN. *l. c.* fig. 47.

Raja Postinaca

Muraena Helena

———— *Serpens*

———— *Cæca*

Gadus Mediterraneus

Blenius Lumpenus

Zeus Faber

Sparus Sargus

Labrus Turdus

Glupea Harengus.

MARQUIS GAZOLA.

ORDINE II.

Pesci dei Mari dell' Asia.

Chætodon vespertilio. BLOCH ICHTH. VI. Tab. 199. fig. 2.

———— *bisfasciatus.* SEBA. Mus. 3. Tab. 26. fig. 23.

———— *pinnatus.* SEBA. *l. c.* Tab. 25. fig. 15.

———— *niger.* SEBA. *l. c.* Tab. 25. fig. 5. a.

———— *canescens.* SEBA. *l. c.* Tab. 25. fig. 7.

———— *lineatus.* SEBA. *l. c.* Tab. 25. fig. 1.

———— *fuscus.* SEBA. *l. c.* Tab. 26. fig. 22.

———— *striatus.* BLOCH. *li. c.* Tab. 205. fig. 1.

———— *macrolepidotus.* SEBA. *l. c.* Tab. 25. fig. 8.

Fistularia chinensis. VALENT. Ind. 3. fig. 23.

Pegasus natans. BLOCH. Ictb. IV. Tab. 121. fig. 3. 4.

———— *volans.* LINN. *l. c.* pag. 418.

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Polynemus

- Polynemus paradiseus*. LINN. *l. c.* pag. 522.
Zeus ciliaris? BLOCH. *Ictb.* VI. *Tab.* 191.
 ——— *triurus*. Huic valde adfinis *Zeus faber* LINN.
Tetraodon lagocephalus. SEBA. *l. c.* *Tab.* 23. *fig.* 5. 6.
Clupea Thrissa. BROUSSON. *Ictb.* Dec. I. *Tab.* 10.
Perca unicolor. SEBA. *l. c.* *Tab.* 27. *fig.* 10.
Esox amboinensis. RUYSCH. *Ambcin.* *Tab.* 14. *fig.* 2.
Diodon reticulatus. SEBA. *l. c.* *Tab.* 23. *fig.* 3. 4.
Labrus ferrugineus. SEBA. *l. c.* *Tab.* 31. *fig.* 5. 6.
Muræna serpens. WILLOUGH. *l. c.* *Tab.* G. 10. *fig.* 1.
Callyonimus indicus. LINN. *l. c.* pag. 434.
Sparus argenteus. SEBA. *l. c.* *Tab.* 27. *fig.* 13.
Pegasus Draconis.—MARQUIS GAZOLA.

ORDINE III.

Pesci dei Mari dell' Africa.

- Sparus dentex*. WILLOUGH. *lib. c.* *Tab.* X. 7. *fig.* 6.
Ostracion Turritus.—MARQUIS GAZOLA.

ORDINE IV.

Pesci Marini dell' America meridionale.

- Raja muricata*. MARCGR. *Brazil.* pag. 175.
Scomber cordyla. WILLOUGH. *l. c.* *Tab.* 5. 18. *fig.* 1.
 ——— *coorza Pisonis*. WILL. *l. c.* *Tab.* M. 5. *fig.* 2.
Esox brasiliensis. MARCGR. *l. c.* pag. 168.

Chatodon

Chætodon arcuatus. BLOCH. VI. *Tab.* 201. *fig.* 2.
 ——— *trioptegus*. SEBA. *l. c.* *Tab.* 25. *fig.* 4.
 ——— *acarauna*. WILL. *l. c.* *Tab.* 0. 5.
 ——— *fusiformis*. *An. Ch. rhomboides?* BLOCH. *l. c.* *Tab.* 209.
Polynemus quinquarius. SEBA. *l. c.* *Tab.* 27. *fig.* 2.
 ——— *plebejus*. BROUSSON. *l. c.* *Tab.* 8.
Loricaria plecostomus. MARCGR. *l. c.* *pag.* 166.
Silurus bagre. SEBA. *l. c.* *Tab.* 29. *fig.* 2.
Gobius strigatus. BROUSSON. *l. c.* *Tab.* 1.
Zeus vomer. BLOCH VI. *Tab.* 193. *fig.* 2.

Diodon Orbicularis
Mulus Gigas
Exocetus Evolans
Sparus Argenteus
Coryphæna Hippurus
Chætodon Saxatilis
 ——— *fasciatus*
 ——— *ciliaris?*
 ——— *curacao*
 ——— *nigricans*
 ——— *cornutus*
 ——— *lanceolatus*
 ——— *orbis*
 ——— *arcuatus*
 ——— *aculeatus*
Silurus Fasciatus.

MARQUIS GAZOLA.

O R D I N E V.

Pesci marini dell' America settentrionale.

- Balistes monoceros*. CATESBY. *Carol.* 21. *Tab.* 19.
Chætodon chirurgus. BLOCH. VI. *Tab.* 208.
Esox umbla minor. CATESB. *l. c.* *Tab.* 1. *fig.* 1.
Fistularia tabacaria. WILLOUGH. *l. c.* *Tab.* P. 6. *fig.* 4.
Exocetus evolans. CATESB. *l. c.* *Tab.* 8. *fig.* 1.
Gasterosteus carolinus. LINN. *l. c.* pag. 490.
Gadus tau. WILLOUGH. *l. c.* *Tab.* N. 12. *fig.* 3.

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| <i>Gasterosteus Canadus</i> | } | MARQUIS GAZOLA. |
| ———— <i>Volitans</i> | | |
| <i>Perca Venenosa</i> | | |
| —— <i>Punctata</i> | | |
| —— <i>Trifurca</i> | | |
| <i>Scomber Fasciatus</i> | | |
| <i>Clops Saurus.</i> | | |

O R D I N E VI.

Pesci di acqua dolce, esotici.

- Tetraodon ocellatus*. Ex Indiis. SEBA. *l. c.* *Tab.* 23. *fig.* 7. 8.
Chætodon argus ex Indiis. BLOCH. *l. c.* *Tab.* 204. *fig.* 1.
Gobius ocellaris. Ex Ins. otheit. BROUSSON. *lib. c.* *Tab.* 2.
Clupea cyprinoides. Ez Brasilia. BROUSSON. *lib. c.* *Tab.* 9.
Zeus insidiator. Ex Surate. BLOCH. *l. c.* *Tab.* 102. *fig.* 23.

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|----------------------------------|---|-----------------|
| <i>Tetraodon Lagocephalus</i> | } | MARQUIS GAZOLA. |
| <i>Chætodon Glaucus</i> | | |
| <i>Sparus aurata</i> ex America. | | |

La grandezza di alcuni Pesci è rimarcabile, essendovene di quelli che giungono alli 40 pollici di lunghezza. Non si notano poi, nel presente Catalogo, le singolarità di ciascheduna petrificazione, per servire alla brevità propria di un Indice.

Nel Gabinetto prefato, oltre ai Pesci fossili, si conservano le seguenti petrificazioni di altre Classi di corpi organizzati, cioè

- I. Fitoliti di fuchi e felci europee ed esotiche. Del Monte Bolca.
- II. Zoofiti di Madrepore, Ifidi, Millepore ecc. dei Monti Veronesi.
- III. Elmintoliti di Conchiglie univalvi, e bivalvi di molti mari, con echiniti, stelle marine, e congierie delle medesime. Delle Montagne predette.
- IV. Entomoliti rari di granchi, insetti apteri, e dipteri d'Europa, e di America. Del Monte Bolca.
- V. Osteoliti di Animali ruminanti, e di altri quadrupedi d'insigne grandezza. Di Romagnano, e di altre parti del Veronese.

*On the POWER of FIXED CAUSTIC ALKALINE
SALTS to preserve the FLESH of ANIMALS from
PUTREFACTION. In a Letter to the Reverend
GEORGE GRAYDON, &c. from the Reverend HUGH
HAMILTON, D. D. &c.*

S I R,

THE ingenious paper you communicated to the Royal Irish Academy, on the fishes that have been found enclosed in stone in the quarry at Monte Bolca, brought to my recollection some observations I had made many years ago, on the power that alkaline salts, even when highly caustic, have to preserve animal substances. I mentioned to you some of these observations, and you have desired I should give you a fuller account of them, as you thought they in some measure coincided with the theory you had delivered, concerning the preservation of the more solid parts of the fishes found in quarries of lime-stone.

Read April
5, 1794.

I CAME.

I CAME to the knowledge of this power of alkaline salts, I may say, accidentally. I had a wish to procure some kind of alkaline liquor that might be safely taken, for the purpose of correcting acidities in the stomach. I knew that a solution of salt of tartar was exceedingly offensive to the taste, and if it was of strength sufficient to neutralize any quantity of acid in the stomach, it could not be swallowed without danger to the passages, from its causticity. It occurred to me, that its causticity might probably arise from its having a strong affinity to something or other, to get at which it burned or destroyed the texture of the flesh. If this should be the case, it was natural to suppose, that this salt, if intimately mixed with flesh, would saturate itself with whatever it was that it had such a strong appetite for, and, being so saturated, it would act no further on our flesh, and might, without danger, be taken inwardly. To try this, I first enclosed some bits of lean raw mutton in a vial with a strong solution of salt of tartar; but, after standing several days, no such alteration as I expected appeared in the liquor. I was willing to account for this, by supposing the salt had a greater affinity to the water than to any thing in the flesh; I therefore cut some flesh from the breast of a turkey, roasted the day before, and made it as dry as I could; this I pounded in a mortar, adding by degrees some dry and finely powdered salt of tartar*, until I thought there was enough, for I had no rule to judge by; the mixture grew moist,

* This salt had been sent to me rendered caustic by quick-lime, though I had not desired it.

moist, and when it was sufficiently pounded, I spread it into a thin cake on an earthen dish, and set it before the fire, and it soon became quite dry. I found it had then a saponaceous mild taste, for the taste of the salt was scarcely perceptible. Having macerated this flesh in warm water, and poured off the clear liquor, I found it effervesced with vinegar, which shewed, that the salt was not so far neutralized, but that it would unite itself with an acid, so that I considered it as a mild alkaline liquor, such as I sought for: However, that I might have an opinion from a person of skill on the subject, I wrote to my late worthy and ingenious friend, Doctor Mc. Bride, and acquainted him with the preparation I had made, and the intention of it. In his answer, he was pleased to say he approved of the idea, and would make some of the liquor I described, and let me know what he thought of it. He afterwards wrote to me, and said he had tried the alkaline liquor, and thought it might prove a useful medicine, particularly as it might be mixed with milk and given to children, who have often acids in their stomachs. He also mentioned a physician then in Dublin, to whom he recommended the liquor, and who had found great benefit from it. I first made this liquor in the year 1771, and in the year 1777, being then at Bath, I met with an account of some experiments made by Mr. Bewly, an ingenious chymist, which plainly proved that fixed air is an acid, and saturates alkaline salts; this at once informed me, what it was in the flesh of an animal, that alkaline salts had such a strong affinity to. At the same time I got from London one of Doctor Nooth's glass machines for impregnating water with fixed air, and to the

water I added salt of tartar; after this, you may suppose, I thought no more of my alkaline broth, having got a way of obtaining what I wanted in a much more elegant manner.

I WOULD not have given you this long detail of a matter now uninteresting, had you not desired me to write the whole of what I had told you in our conversation. The only thing now worth attention in the experiment I have related is, that it discovered a power in even caustic alkaline salt to preserve flesh, I may say, incorruptible; though it has been generally imagined that such salts would consume it. I have some flesh prepared with these salts, in the year 1772; for, finding some bits made the year before had continued unaltered, I made some more, and laid it by to see how long it would keep, and what alterations it would undergo. I made it into a cake, and when quite dry I cut it into round bits about the size of half a crown, and put them into a drawer in my desk; I shewed some of them to Mr. Kirwan the summer before last, when I had the honour of receiving a visit from him at Armagh, and a few months ago I found several pieces in another drawer, *where they have lain near two and twenty years, and remain unaltered; when they are broken, the pieces hang together by fibres, and look like a piece of plaster taken from a wall; the fibrous or stringy parts of the flesh do not seem to have been corroded or dissolved by the salt.*

AFTER I knew that fixed air was an acid, and saturated alkaline salts, I began to form conjectures about the means by which

which these salts had so entirely prevented putrefaction in the flesh to which they were united. Animal substances afford much volatile alkali, and now they are known to contain also a volatile acid gas. While these two volatile principles continue united with each other, they may prevent any material change from taking place in the substance; but if one of them by any means escapes, the other will follow; the acid seems to be the most volatile, and escapes first, though we may not be sensible of its escape, because it has no such strong smell as the alkali has. The letting loose these volatile principles seems to be the beginning of putrefaction. If this be the case, we may see the reason why flesh, growing putrid, is restored to sweetness by fixed air, that acid replacing what had escaped, and retaining the volatile alkali. It is probably on this account that the ærial acid is found to be of use in stopping the progress of some putrid diseases; it seems to act as a sort of pickle. If vinegar preserves flesh by keeping its volatile alkali united with this acid which is not volatile, we may expect a fixed alkali will have a like effect in preserving flesh, by expelling the weaker volatile alkali, and uniting itself to the volatile acid, which will therefore be retained. This I found to be really the case; for, while the flesh and alkali were combining in the mortar, a very strong smell arose like that of *sal volatile*; and at one time that I used a brass or metal mortar, I perceived its edges to be tinged with blue, which shewed the metal had been affected by a volatile alkali.

THERE

THERE seems to be a good reason why fixed alkaline salts should preserve flesh much longer than any fluid acid, such as vinegar, can do; for when the alkaline salt combines with the flesh, it expells what is volatile, the mass grows hard, and it is easily reduced to a state of dryness, in which no sort of fermentation or any intestine motion can take place, and therefore there is nothing that can effect a change in this compound substance: whereas when an animal or vegetable substance is immersed in vinegar, a very heterogeneous mixture is formed, which, in length of time, will be very apt to run into a sort of fermentation, with an intestine motion among the minute particles, and this will bring on some change in the texture of the substance, and every fermentation, when long continued, ends in putrefaction, which, indeed, is said to be the last stage of fermentation.

WHETHER the conjectures I have offered on this subject be well or ill-founded is but of little consequence; you may rely on the facts I have mentioned, and if you think they throw any light on your theory, you may, if you think proper, submit to the consideration of the Royal Academy this paper as an appendix to your's.

I am, Sir,

Your very humble servant,

Dublin,
April 2, 1794.

HUGH HAMILTON.